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(12) (19) (CA) **Brevet-Patent**

(11) (21) (C) **2,053,505**
(22) 1991/10/16
(43) 1992/04/18
(45) 1999/04/13

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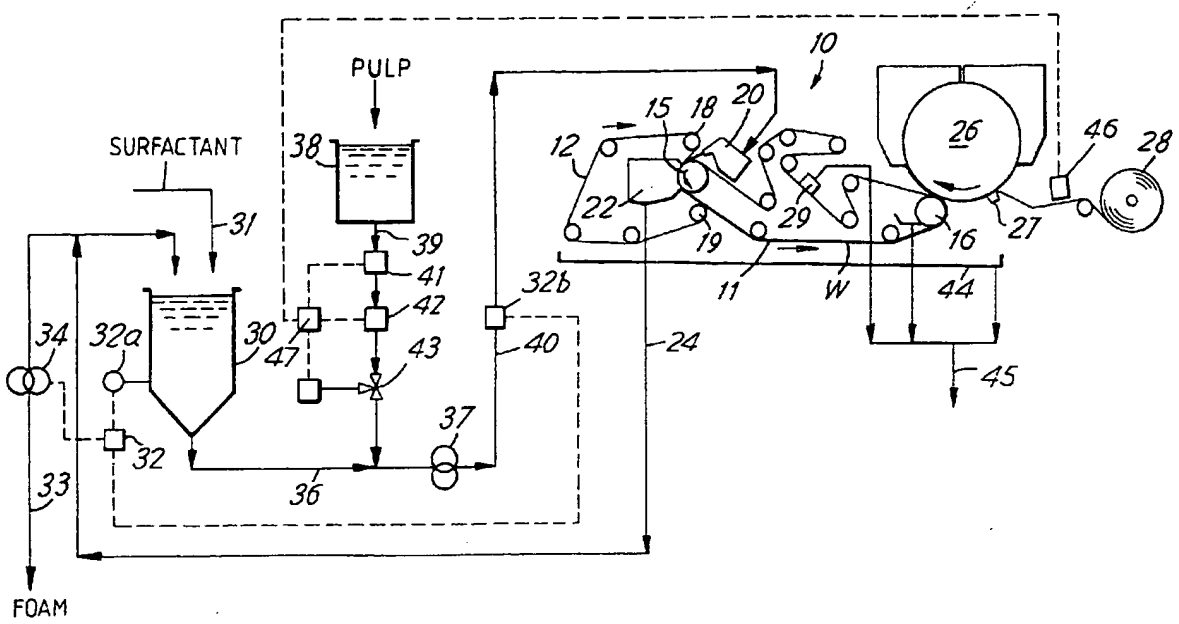
(51) Int.Cl.[6] D21F 11/00
(30) 1990/10/17 (07/599,149) US

(54) **METHODE ET APPAREIL DE PRODUCTION DE MOUSSE**
(54) **FOAM FORMING METHOD AND APPARATUS**



(57) Cette invention concerne un procédé et une installation de formation d'une nappe fibreuse moussée dont la composition de fabrication est obtenue par malaxage d'une suspension aqueuse diluée de fibres dont la densité se situe entre environ 0,5 et environ 7 pour cent en poids de fibres avec suffisamment de mousse aqueuse renfermant un surfactant et ayant une teneur en air entre environ 55 et environ 80 pour cent en volume pour constituer une composition de fabrication moussée renfermant entre environ 0,1 à environ 3 pour cent en poids de fibres acheminée directement à la toile de formation simple ou double d'une machine à papier. Le procédé prévoit l'ajout de surfactant d'appoint et le rejet de la mousse aqueuse excédentaire selon les besoins pour maintenir le volume de liquide moussé voulu.

(57) Apparatus and process for producing foam formed fibrous web in which the furnish is made up by mixing a thin water slurry of fibers at a consistency in the range of from about 0.5 to about 7 weight percent fibers with sufficient aqueous foam containing a surfactant and having an air content in the range of from about 55 to about 80 percent by volume to form a foamed fiber furnish containing from about 0.1 to about 3 weight percent fibers which is supplied directly to the forming felt or wire of a twin wire papermaking machine, adding makeup surfactant and discarding excess agueous foam from the process as required to maintain the desired volume of foamed liquid therein.

Abstract

2053505

Apparatus and process for producing foam formed fibrous web in which the furnish is made up by mixing a thin water slurry of fibers at a consistency in the range of from about 0.5 to about 7 weight percent fibers with sufficient aqueous foam containing a surfactant and having an air content in the range of from about 55 to about 80 percent by volume to form a foamed fiber furnish containing from about 0.1 to about 3 weight percent fibers which is supplied directly to the forming felt or wire of a twin wire papermaking machine, adding makeup surfactant and discarding excess aqueous foam from the process as required to maintain the desired volume of foamed liquid therein.

FOAM FORMING METHOD AND APPARATUS

2053505

This invention relates to an improved foam forming process and apparatus for the manufacture of high quality fibrous webs. In one of its more specific aspects it relates to an improved method and apparatus for preparing low basis weight webs of exceptionally high uniformity, particularly tissue suitable for use as facial tissue and bathroom tissue, and in personal hygiene products.

Foam forming processes for tissue manufacture are known in the art. Among the prior art processes for producing webs by various foam forming methods are those disclosed in U.S. Patents Nos. 3,716,449; 3,938,782; 3,871,952; and 3,837,999. These prior art patents have in common the teaching of separate foamed liquid generating systems wherein liquid containing a surface active agent is subjected to turbulence in the presence of air to create foamed liquid as carrier fluid for making up a foamed fiber furnish.

U.S. Patents Nos. 3,876,498; 3,846,232; 4,062,721; and 3,746,613, and 4,543,156 disclose preferred papermaking machines useful in the process of this invention.

In a preferred embodiment of the invention, the fibrous web forming apparatus is either a papermaking machine known in the art as a crescent former or one of the twin wire type, as described in U.S. 4,543,156 wherein one of the forming wires acts as a turbulence generator producing the foamed liquid in which fibers are dispersed to make up the foamed fiber furnish. In these machines, foamed liquid is generated at the forming wire without the need for separate turbulence generating devices. Control of the foamed liquid as to desired air content, viscosity, specific gravity, and

related characteristics is accomplished without the need for special foam generators.

U.S. Patents Nos. 4,443,299 and 4,543,156 disclose processes for foam forming fibrous webs in which the foamed liquid is produced on the forming wires, stored in a silo, and totally recycled to minimize loss of surfactant from the system. In order to achieve this objective, it is necessary to dewater the wet feed pulp to a consistency in the range of 8 to 50 weight percent fiber, preferably in the range of 15 to 35 weight percent fiber, prior to formation of the desired foam and fiber furnish. The foamed fiber furnish to the headbox is formed by combining a recycle stream of the foam with a pre-formed slurry obtained by dispersing this de-watered high consistency fiber stock in foam.

Control of this papermaking process, however, can be tricky because the foamed fiber furnish is very difficult to meter accurately on a dry fiber basis before it is added to the forming loop.

Conventional metering and control devices commonly used in papermaking have maximum accuracy over only fairly narrow ranges when used with slurries of fiber in liquid water and, even to date, applicants are not aware of reliable commercially available devices for measuring consistency of dispersions of fiber in foams used in papermaking processes which contain upwards of 50% air by volume.

Because commercially available consistency measuring devices typically measure viscosity-like effects of the flowing fiber slurry, these devices are usually considered highly reliable only over a fairly narrow region of consistency centered around 2 to 3% fiber by weight. As the consistency drops into the neighbourhood of 1% and below, the effect of fiber content on the measured "viscosity" becomes increasingly slight. As the consistency rises into and above the region of 5 to 7%, the effect of even small changes in consistency on the measured "viscosity" becomes increasingly pronounced as the "viscosity" rises very rapidly. Accordingly, it can become difficult to continuously measure consistency of a flowing fiber slurry comprising fiber percentages above those ranges which are currently employed widely in conventional papermaking. At the lower end of the curve, devices, typically employing optical principles, are becoming available for measuring lower and lower consistencies. However, the upper end of the consistency range remains problematical. These limitations are described more fully in: James P. Casey, (editor) Pulp and Paper, Chemistry and Chemical Technology, Third Edition, 1980, volume 2, pp. 885-894.

The present invention enables the consistency and basis weight in a papermaking process employing foam in the forming loop to be controlled using conventional, commercially available consistency and flow control devices in regions where these devices possess the requisite degree of accuracy. Thus, the present invention is directed to a papermaking process and apparatus which enables conventional

devices to be employed to achieve a satisfactory degree of control for commercial operations at high speed, yet the required equipment is considerably simplified as compared to the hitherto known papermaking procedures employing foam.

In the process of this invention, the furnish to the headbox is formed by combining a stream of foam with a stream comprising a slurry of fiber in an aqueous liquid of the type normally controlled in papermaking operations. Accordingly, satisfactory control of the amount of fiber supplied to the headbox is considerably facilitated.

In the present invention the foamed fiber furnish is made up from an aqueous slurry of natural or synthetic fibers or mixtures of fibers and foamed liquid carrier just prior to its introduction to the headbox. The pulp slurry supplied to the system has a consistency in the range of only about 0.5 to about 7 weight percent fibers, preferably in the range of from about 2.5 to about 45. weight percent. The pulp slurry is added to a foamed liquid comprising water, air and surfactant containing 55 to 80 percent air by volume forming a foamed fiber furnish having a consistency in the range of from about 0.1 to about 3 weight percent fiber by simple mixing from natural turbulence and mixing inherent in the process elements. The addition of the pulp as a low consistency slurry results in excess foamed liquid recovered from the forming wires. The excess foamed liquid is discharged from the system and may be used elsewhere or treated for recovery of surfactant therefrom by the method disclosed in Canadian Patent Specification 2,053,504, filed October 16, 1991.

Thus, according to the present invention, there is provided a method of making a fibrous web or tissue from a foamed fiber furnish comprising an aqueous dispersion of natural or synthetic fibers or both on a moving foraminous support characterised in that said foamed aqueous dispersion is obtained by combining an unfoamed aqueous slurry of fibers containing 0.5 to 7 percent fiber with a foamed liquid comprising water, air and a surface active agent to form a foamed fiber furnish containing from 50 to 80 percent air by volume and from 0.1 to 3 weight percent fiber, based on the dry weight of the fibers.

The invention also provides a method of making a fibrous web or tissue from a foamed aqueous dispersion of natural or synthetic fibers or both on a moving foraminous support which comprises:

a. preparing an aqueous slurry of fibers containing from 0.5 to 7, preferably 2.5 to 4.5, weight percent fibers based on the dry weight of the fibers,

b. combining said aqueous slurry of fibers with a foamed liquid comprising water, air and a surface active agent to form a foamed fiber furnish containing from 50 to 80, preferably 60 to 70, percent air by volume in an amount sufficient to form a foamed fiber furnish containing from 0.1 to 3, preferably 0.2 to 1.2, weight percent fibers based on the dry weight of the fibers, and

c. feeding said foamed fiber furnish to said foraminous support in an amount sufficient to form a fibrous web and collecting foamed liquid removed from said web at said foraminous support, and preferably recycling the collected foamed liquid as a source of foamed liquid to be combined with said aqueous slurry.

Also according to the invention, there is provided apparatus for making a fibrous web or tissue from a foamed fiber furnish containing from 50 to 80 percent air by volume and from 0.1 to 3 weight percent fibers based on the dry weight of the fibers and obtained from an aqueous slurry of fibers having a consistency of from 0.5 to 7 weight percent fibers based on the dry weight of the fibers and a foamed liquid comprising water, air and a surface active agent containing from 50 to 80 percent air by volume, said apparatus comprising:

(i) a moving foraminous support;

(ii) slurry supply means for supplying said aqueous slurry of fibers;

(iii) foam supply means for supplying said foamed liquid;

(iv) furnish makeup means for combining said aqueous slurry of fibers with said foamed liquid to form said foamed fiber furnish and including a positive displacement pump;

(v) means for depositing said foamed fiber furnish on said foraminous support in an amount sufficient to form a fibrous web;

(vi) consistency determining means for measuring the consistency of said aqueous slurry of fibers;

(vii) flow rate determining means for measuring the flow rate of said aqueous slurry of fibers;

(viii) mass sensitive means for measuring the basis weight of said web; and

(ix) furnish consistency control means comprising means responsive to said mass sensitive means and to said consistency determining means for controlling the flow rate of said aqueous slurry of fiber to said furnish makeup means.

The foraminous support is preferably a paperkaking felt and the apparatus is suitably

a) a papermaking machine comprising a forming support, a headbox for distribution of the foamed fiber furnish on the forming support to form a wet web, a pressing wire for expressing liquid from the wet web with formation of foamed liquid by squeezing the web between the pressing wire and the forming support and means for recovering foamed liquid therefrom;

b) a storage tank or silo for foamed liquid;

c) means for delivering the foamed liquid from the storage silo to the headbox of the papermaking machine including a positive displacement pump;

d) means for supplying the fiber slurry; and

e) means for combining said fiber slurry with said foamed liquid forming a dispersion of fibers in foam, supplying said dispersion of fibers in foam to the headbox as a foamed fiber furnish and maintaining the consistency of the foamed fiber furnish supplied to said headbox in the range of from about 0.1 to about 3% by weight.

Preferably, the fibre slurry is introduced into the foamed liquid at the inlet to the pump.

The apparatus preferably also includes means for maintaining a constant inventory of foamed liquid in said silo and for discharging excess foamed liquid recovered from the foraminous support, said means including control means responsive to signals from a) a pressure sensor for measuring the pressure of a head of said foamed liquid above said sensor in said silo and b) means for determining the density of the foamed liquid.

Thus, according to yet a further aspect of the invention, there is provided apparatus for the preparation of a fibrous web from a foamed aqueous dispersion of natural or synthetic fibers or both which comprises in combination:

a) a papermaking machine comprising a forming support, a headbox for distribution of a foamed fiber furnish on the forming support to form a wet web, a pressing wire for expressing liquid from the wet web with formation of foamed liquid by squeezing the web between the pressing wire and the forming support and means for recovering foamed liquid therefrom;

b) a storage tank or silo for foamed liquid;

c) means for delivering foamed liquid from the storage silo to the headbox of the papermaking machine including a positive displacement pump;

d) means for combining a water slurry of fibers with said foamed liquid forming a dispersion of fibers in foam to form said foamed fiber furnish supplied to said headbox; and

e) means for maintaining a constant inventory of foamed liquid in said silo and for discharging excess foamed liquid recovered from the foraminous support, said means including control means responsive to signals from a) a pressure sensor for measuring the pressure of a head of said foamed liquid above said sensor in said silo, and b) means for determining the density of the foamed liquid.

The invention will now be described in greater detail with reference to preferred embodiments thereof and with the aid of the accompanying drawings in which:

Fig. 1 is a diagrammatic elevational view of a preferred embodiment of apparatus for carrying out the process of this invention; and

Fig. 2 is a diagrammatic elevational view of an alternate embodiment of apparatus for carrying out the process of this invention.

With reference to Fig. 1, papermaking machine 10, known in the art as a crescent former, corresponds to that described in U.S. Patent No. 3,326,745. The web-forming end or wet end of the papermaking machine includes a liquid permeable forming support such as, for example, felt or fabric 11 and a pressing wire or screen 12 of the type used in the art for wet forming of nonwoven webs. Forming felt 11 is also referred to hereinafter as a forming support means or as a papermaking felt. Forming felt 11 is suitably constructed of synthetic filament woven mesh base with a very fine synthetic fiber batt attached to the mesh base. The forming felt is supported in a conventional manner on rolls including breast roll 15 and couch roll or pressing roll 16.

Pressing wire 12 is similarly supported on rolls including rolls 18 and 19 which are so positioned relative to breast

roll 15 as to cause the pressing wire 12 to converge on the forming felt 11 at the cylindrical breast roll 15 at an acute angle relative to felt 11. The felt 11 and wire 12 move in the same direction at the same speed and in the direction of rotation of breast roll 15. In this machine, wire 12 and forming felt 11 converge at the upper surface of forming roll 15 to form a wedge shaped space or nip into which a jet of a foamed fiber furnish is directed from a pressurized headbox 20. Wire 12 is so tensioned that as it passes over the felt 11 on the surface of breast roll 15, the foamed liquid-fiber dispersion is pressed between wire 12 and felt 11 forcing fluid through wire 12 into saveall 22 where it is collected as foamed liquid having an air content in the range of 50 to 80 percent by volume for reuse in the process. The wet web W formed in the process is carried by felt 11 to pressing roll 16 where it is transferred to the drum 26 of a Yankee dryer. Fluid is pressed from the wet web by pressing roll 16 as the web is transferred to the drum 26 of the dryer where it is dried and creped by creping blade 27. The finished web is collected on take-up roll 28. It will be evident that some of the surfactant necessary to form the foamed aqueous liquid used in the process normally remains in the web.

Foamed liquid collected from the foamed fiber furnish in saveall 22 is returned through line 24 to foam silo 30. White water from pit 44, Uhle box 29 and pressing roll 16 may be combined in flow line 45 and separately processed for recovery of surfactant and fibers from the fluid.

Concentrated surfactant is added to the foam silo 30 through line 31 as required to make up losses from the system. A substantially constant inventory of foamed liquid is maintained in the foam silo 30 by indirectly regulating the rate of flow from line 24 to silo 30. Excess foamed liquid is drawn from line 24 by pump 34 and discharged through line

33 at a rate determined by pump speed controller 32 responsive to signals from pressure sensor 32a at the base of silo 30 and from density meter 32b in line 40.

Dwell or retention time in the silo is preferably in the range of from about 30 seconds to 1 minute. Foamed liquid is withdrawn from foam storage silo 30 through line 36 to a positive displacement fan pump 37. A pulp slurry containing of the order of 0.5 to 7 weight percent fiber, preferably in the range of from about 2.5 to about 4.5 percent fiber, is drawn from machine chest 38 through line 39 and in this preferred embodiment is added to the foam from line 36 at the inlet to the fan pump 37 in the amount necessary to form the foamed-fiber furnish of the desired consistency in the range of from about 0.1 to about 3 weight percent, preferably in the range of 0.3 to 1.2 weight percent, for the production of fibrous web on the forming felt 11. The rate of pulp feed to the fan pump is controlled by valve 43 responsive to controller 47 which receives signals from basis weight meter 46, consistency meter 41 and flow meter 42, all of conventional design to produce webs of the desired basis weight at the production speed of the felt 11 on machine 10. Typical basis weights of the uncreped web are in the range of from about 4 pounds per 3000 square foot ream to about 35 lb/rm or more. Preferred basis weights are those within the range of from about 6 to about 25 lb/rm. From the fan pump 37, the foamed-fiber furnish is delivered through line 40 to the headbox 20 of the papermaking machine.

In a preferred embodiment of the process of this invention, water from a suitable source, not illustrated, is added to the foam silo 30 with sufficient surfactant to produce the desired foamed liquid. For example, an aqueous solution of a suitable anionic surfactant, such as an alpha olefin sulphonate, available from Witco Chemicals, Inc., New York, N.Y. may be used to produce a satisfactory aqueous foam at a

preferred concentration in the range of from about 100 ppm to about 350 ppm by weight. A number of surfactants suitable as a water additive for purposes of the present invention are available on the market, being generally classified as nonionic, anionic, cationic or amphoteric. The surfactant concentration required usually will be in the range of 150 to about 1000 ppm by weight. A preferred nonionic surfactant is a peg-6 lauramide marketed under the Trade Mark Mazamide L-5AC by Mazer Chemical Co., Chicago.

Selection of a class of surfactant is dependent upon chemical characteristics of such other additives as may be commonly used in the manufacture of fibrous webs. These other additives include, singly or in homogeneous mixtures thereof, latexes, binders, debonding agents, dyes, corrosion inhibiting agents, pH controls, retention aids, creping aids, additives for increasing wet strength or dry strength as well as other substances commonly used in papermaking processes.

U.S. Patent Nos. 3,716,449 and 3,871,952 disclose specific nonionic, anionic, and cationic surfactants, including some classified as amphoteric surfactants, which are suitable for practice of the present invention. It is to be understood that there are a number of other surfactant materials available which are capable of modifying the interfacial tension between water and gas or air to form a semi-stable foam suitable as aqueous carrier medium suitable for use in the process of this invention.

A preferred method of generating the aqueous foam as the carrier of the fibers in the furnish is that disclosed in U.S. Patent 4,443,299. As a specific example, foam carrier liquid is generated by driving the forming felt 11

and wire 12 at a speed of about 2500 feet per minute (fpm), with the tension of the wires adjusted to a range of from about 20 pli (pounds per linear inch) to about 60 pli, suitably about 30 pli. Variable speed, positive displacement fan pump 37 is energized to pump a water-surfactant solution, or foamable liquid, from silo 30 to pressurized headbox 20, from which a foamable liquid jet is directed to the nip formed at the juncture of the forming felt 11 and wire 12. The pressure of the foamed liquid (and foamed liquid-fiber furnish) delivered to headbox 20 from pump 37 usually will be within the range of from about 5 to about 100 pounds per square inch gauge (psig). The pressure and flow rate of the liquid are regulated to achieve a jet velocity of from about 90% to about 150% of the speed of the forming felt both during foam formation and web formation. Preferably, the speed of the jet is about 110% of the speed of the forming felt 11. Forming felt speeds in the range of from about 1000 fpm to about 7000 fpm or more may be employed in the formation of the web W.

As the foamable liquid impinges on the forming felt 11, it is distributed over its surface, and the pressure created as the outer wire 12 moves onto the felt 11, combined with the force of liquid jet from the headbox 20 on the outer wire, causes the foamable liquid to flow through interstices of outer wire 12 into the saveall 22. Closure of the wire 12 on forming felt 11, together with their linear movements and the force of impingement of liquid jet thereon, cooperate to produce combined compressive and shear forces on the foamable liquid passing through wire 12 sufficient to entrain air traveling with the wire 12 and felt 11 as well as air in their interstices, and to generate the desired foamed liquid.

Foamed liquid is collected in saveall 22 and returned to the upper region of silo 30 by way of conduit 24. Foamable

liquid and foamed liquid is pumped again, in a continuous cyclic manner from the silo 30 by fan pump 37 to headbox 20 for passage through wire 12 and return to the silo until the desired consistency of foamed liquid is obtained. Typically, over an operating period of about 12 to 30 cycles of circulation of foamed liquid and foamable liquid through the system, the air content of the liquid is increased from almost nil to a preferred value in the range of from about 60 to about 70 percent air by volume with a maximum bubble size, for example, in a range from about 20 microns to about 200 microns, i.e., of a size less than the lengths of the fibers which are used in the furnish. Optimum relationships of bubble dimensions to fiber dimensions are dealt with in the referenced U.S. Patent Nos. 3,716,449 and 3,871,952 and are preferred in the process of the present invention.

As pointed out hereinabove, the pulp slurry supplied to the system from machine chest 38 introduces water into the system at a greater rate than that of the rate of water removal from the system by the wet web. The excess water is removed from the process as foamed liquid through line 33. the water contained in the foamed liquid leaving the system through line 33 may be used as such in other processes or treated for removal of surfactant therefrom before it is discharged into a pond or stream to avoid pollution of the environment. A preferred method of treatment of the excess foamed liquid is disclosed in the aforementioned Canadian Patent Specification 2,053,504. In this preferred embodiment, the quantity of excess foamed liquid discharged from the system is controlled by pump 34 in line 33 in response to a pressure sensor 32 at the base of silo 30.

The air content of the foamed liquid is maintained within the desired range by varying the concentration of the surface active agent in the foamable aqueous carrier liquid

which comprises air, water, and surfactant. Some of the surfactant is continuously removed from the system in the finished web. The wet web at the point of its transfer from felt 11 to drum 26 contains foamable liquid. Drying of the web on drum 26 removes water from the web leaving some surfactant. Makeup surfactant is added as required through line 31 to silo 30. The properties of the foamed liquid are dependent on air content in the range of from about 55 to 80 percent air by volume; the bubble size at atmospheric pressure being in the range of from about 20 to about 200 microns in diameter; and the concentration of the selected surfactant.

Because of the head induced by the pump 37, the bubble size of the foamed liquid in the headbox is reduced, the average bubble size therein typically being in the range of about 5 to about 100 microns. The bubble size increases as pressure is decreased during passage of the foamed liquid through line 40. The pressure drop through nozzle 20 is generally in the range of about 5 to 100 psi (pounds per square inch), and is a function of the jet velocity required. As the foam expands across the nozzle, the bubbles become larger, the density of the foam decreases and the viscosity of the foam increases. The fibers are distributed randomly but uniformly between the felt 11 and wire 12 to produce a web having a high degree of uniformity of fiber distribution as indicated by standard tests and visual inspection of the web.

Fig. 2 illustrates the process of this invention as applied to a twin wire machine. In this instance, the numeral 11' refers to the forming wire and the numeral 12' to the pressing wire. Pressurized headbox 20' injects a jet of foamed furnish into a nip formed between wires 11' and 12' on the lower surface of breast roll 16'. Such twin wire

machines are well known in the art and are described in greater detail in U.S. Patent 4, 543,156.

As illustrated in Fig. 2, foamed liquid from saveall 22' flows through line 24' to silo 30'. Surfactant solution is supplied as required through line 31' to maintain the required air content of the foam in the system as described hereinabove. A substantially constant inventory of foamed liquid is maintained in silo 30' by controller 32' activating pump 34'. Excess foamed liquid is discharged through line 33'. Low consistency pulp slurry is supplied from machine chest 38' as determined by flow control valve 43' responsive to controller 47' in response to signals from basis weight meter 46' which measures the basis weight of the dried web W and from consistency meter 41' and flow meter 42'. The pulp slurry is introduced into foamed liquid from silo 30' in line 36' near the inlet to fan pump 37'. The resultant foamed fiber furnish flows through line 40' directly to pressurized headbox 20'. Thus, the system functions in the same manner as that described hereinabove with reference to Fig. 1.

Example

A foam-formed web is produced on a crescent former papermaking machine, one foot wide, operated at 3000 feet per minute to produce a 9.3 pounds per 3000 square foot ream web from wood papermaking fibers. One thousand gallons per minute (gal/min) of forming foam containing 62 volume percent air and 380 gal/min water containing 300 ppm surfactant with a consistency of 0.31 percent, based on the dry weight of the fibers, is supplied to the forming wires. Fifteen gallons per minute of surfactant-containing liquid leaves the system in the web. Air is entrained in the liquid displaced from the web at the rate of 19 gallons (about 2.54 cubic feet) per minute, regenerating the foam.

Excess foam discharged from the system removes water at the rate of 11 gal/min which is replaced by 26 gal/min entering with the pulp slurry. The pulp slurry consistency is 3.5 weight percent. Makeup surfactant is added as required to maintain the desired concentration of 300 ppm (about 3.9 pounds surfactant per hour). The resultant web is dried and creped on a yankee drum drier forming a high quality web containing a small amount of residual surfactant.

Visual and tactile inspection of the web using standard industry test methods as compared with water laid webs formed on the same machine confirmed superiority of the web formation resulting from the process of this invention.

While the process of this invention has been described herein applied to the formation of the web on a specific type papermaking machine it is to be understood that the process of the invention may be applied equally well to web formation on a flat wire, inclined wire, or suction breast roll machine. It will be appreciated by those skilled in the art that the process of this invention has a number of advantages over those of the prior art in eliminating the need for dewatering the feed pulp and the subsequent need for high energy repulping with foamed liquid for the preparation of the foamed fiber furnish. Among its many advantages are the ability to control accurately the fiber flow rate with conventional pulp consistency meters and flow meters and the ability to make basis weight changes quickly and accurately. The process may be used for wet forming of fibrous webs from an unfoamed aqueous furnish without modification except for discontinuing the surfactant feed to the process. It will be evident that this improved process eliminates much of the equipment required for foam forming as compared with the prior art processes, such as mixing tanks, high shear mixers, turbulence generators, Denver cells, and the like.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of making a fibrous web of tissue from a foamed fibre furnishing comprising an aqueous dispersion of natural or synthetic fibres or both on a moving foraminous support, said foamed aqueous dispersion being obtained by combining an unfoamed aqueous slurry of fibers containing 0.5 to 7 percent fiber with a foamed liquid comprising water, air and a surface active agent to form a foamed fiber furnish containing from 50 to 80 percent air by volume and from 0.1 to 3 weight percent fiber, based on the dry weight of the fibers.

2. A method of making a fibrous web or tissue from a foamed aqueous dispersion of natural or synthetic fibers or both on a moving foraminous support which comprises:

a. preparing an aqueous slurry of fibers containing from 0.5 to 7 weight percent fibers based on the dry weight of the fibers,

b. combining said aqueous slurry of fibers with a foamed liquid comprising water, air and a surface active agent to form a foamed fiber furnish containing from 50 to 80 percent air by volume in an amount sufficient to form a foamed fiber furnish containing from 0.1 to 3 weight percent fibers based on the dry weight of the fibers, and

c. feeding said foamed fiber furnish to said foraminous support in an amount sufficient to form a fibrous web and collecting foamed liquid removed from said web at said foraminous support.

3. A method according to claim 2, wherein the collected foamed liquid removed from the web is recycled as a source of foamed liquid combined with said aqueous slurry.

4. A method according to claim 2 or 3, wherein the foamed liquid combined with the aqueous slurry contains from about 60 to about 70 percent air by volume.

5. A method according to any one of claims 2 to 4, wherein the consistency of the aqueous slurry is in the range of from 2.5 to 4.5 weight percent fiber.

6. A method according to any one of claims 2 to 5 wherein the consistency of the foamed fiber furnish is in the range of from 0.2 to about 1.2 weight percent fiber.

7. Apparatus for making a fibrous web or tissue from a foamed fiber furnish containing from 50 to 80 percent air by volume and from 0.1 to 3 weight percent fibers based on the dry weight of the fibers and obtained from an unfoamed aqueous slurry of fibers having a consistency of from 0.5 to 7 weight percent fibers based on the dry weight of the fibers and a foamed liquid comprising water, air and a surface active agent containing from 50 to 80 percent air by volume, said apparatus comprising:

(i) a moving foraminous support;

(ii) slurry supply means for supplying said unfoamed aqueous slurry of fibers; said slurry supply means being capable of supplying said aqueous slurry at said consistency of from 0.5 to 7 weight percent fibers based on the dry weight of the fibers;

(iii) foam supply means for supplying said foamed liquid;

(iv) furnish makeup means for combining said aqueous slurry of fibers with said foamed liquid to form said foamed fiber furnish; and including a positive displacement pump; and being capable of forming said foamed fiber furnish containing from 50 to 80 percent air by volume and from 0.1 to 3 weight percent fibers based on the dry weight of fibers;

(v) means for depositing said foamed fiber furnish on said foraminous support in an amount sufficient to form a fibrous web;

(vi) consistency determining means for measuring the consistency of said aqueous slurry of fibers;

(vii) flow rate determining means for measuring the flow rate of said aqueous slurry of fibers;

(viii) mass sensitive means for measuring the basis weight of said web; and

(ix) furnish consistency control means comprising means responsive to said mass sensitive means and to said consistency determining means for controlling the flow rate of said aqueous slurry of fiber to said furnish makeup means.

8. Apparatus as claimed in claim 7, further comprising means for collecting foamed liquid subsequent to deposition of foamed furnish on said foraminous support and recycling said collected foamed liquid as a source of said foamed liquid to be combined with said aqueous slurry.

9. The apparatus as claimed in claim 7 or 8, wherein the foraminous support is a papermaking felt.

10. Apparatus as claimed in any one of claims 7 to 9 further including a silo for said foamed liquid and means for maintaining a constant inventory of foamed liquid in said silo and for discharging excess foamed liquid recovered from the foraminous support, said means including control means responsive to signals from a) a pressure sensor for measuring the pressure of a head of said foamed liquid above said sensor in said silo and b) means for determining the density of the foamed liquid.

Fig.1

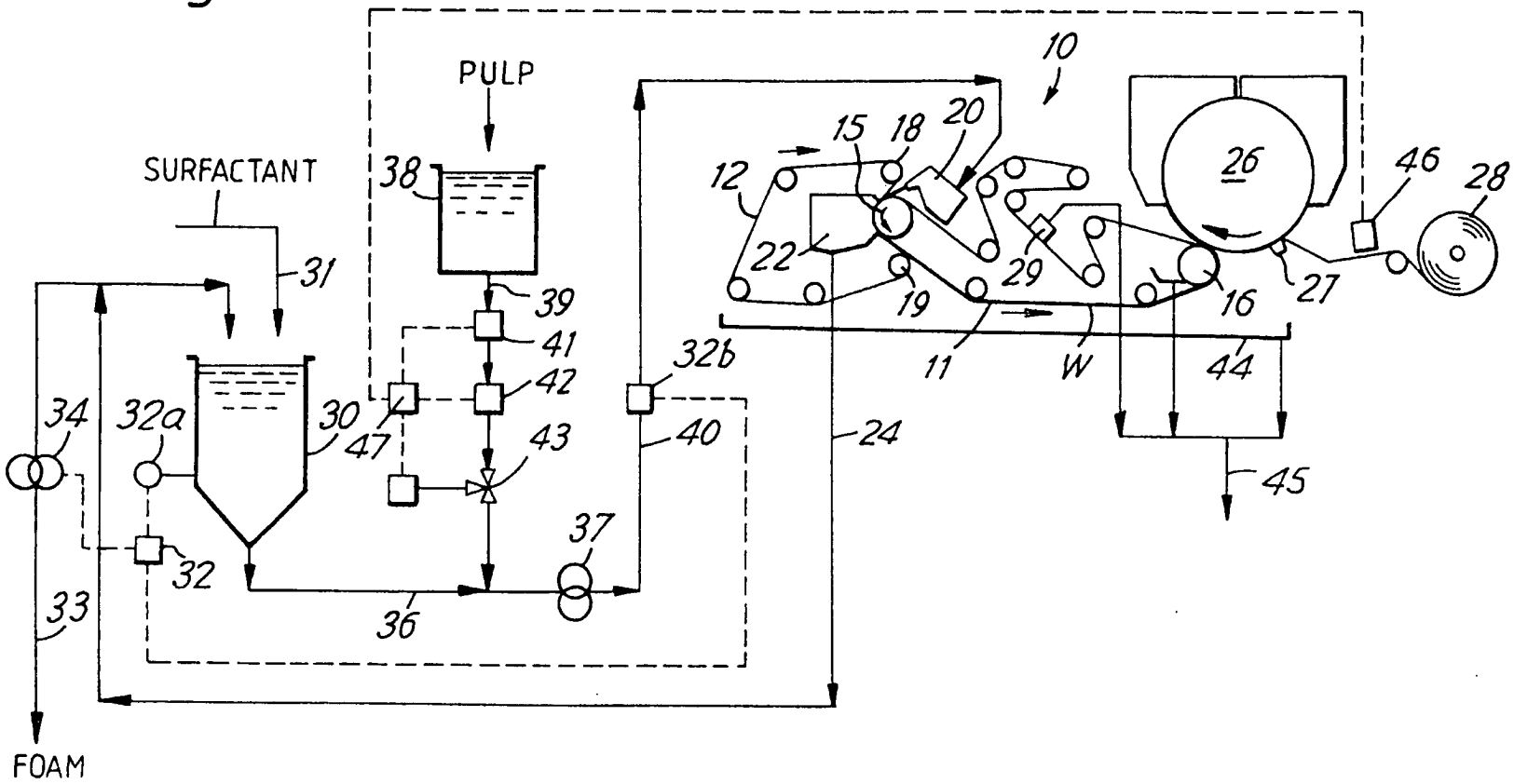


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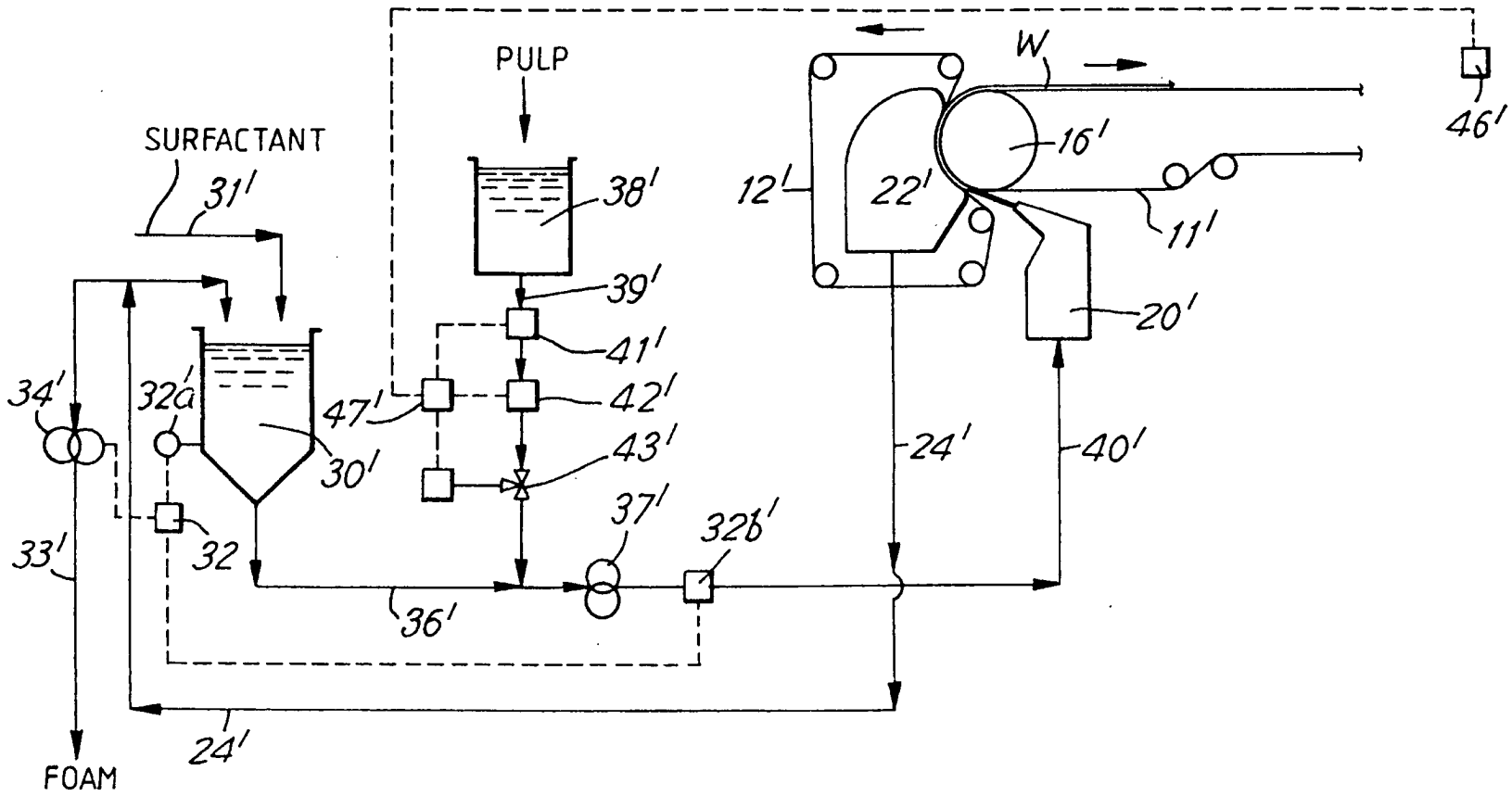
Fig. 2



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